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USSR Report

ENERGY

(FOUO 17/81)

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ELECTRIC POWER

PLANNED DEVELOPMENT OF USSR POWER INDUSTRY OUTLINED

Moscow ELEKTRICHESKIYE STANTSII in Russian No 7, Jul 81 pp 2-5

[Article by P. S. Neporozhniy, minister of USSR Power and Electrification and member-correspondent of the USSR Academy of Sciences: "New Horizons for the Development of Power Production in the USSR"]

[Text] In 1981, a most important event took place in the life of our party and the people--the 26th CPSU Congress. The document of historic importance adopted by the congress, "Basic Directions for the Economic and Social Development of the USSR for 1981-1985 and for the Period to 1990," reflects the economic strategy of the Communist Party for an extended period, the highest aim of which is the realization of a program to improve the public welfare.

Lenin's brilliant formula "Communism is the Soviet government plus the electrification of the whole country" concisely and graphically expresses the main path of communist construction. It was embodied in the specific resolutions of the 26th party congress regarding the further development of the country's fuel and power complex and the accelerated growth of power production as an indispensable condition for carrying out the economic tasks set by the party.

The start of construction on the world's largest fuel and power complex was prescribed by the plan for the State Commission for the Electrification of Russia [GOELRO], developed on the initiative of V. I. Lenin and whose 60th anniversary was noted at the end of 1980. In 60 years, the power production of the country of the Soviets has gone far in its development. At present, about 4 billion kWh of electric power are generated daily in our country. This is half the yearly production established by the GOELRO plan. In 1980 the rated output of the USSR's electric power stations reached 267 million kW, while the annual production of electric power in the last decade doubled and in 1980 amounted to 1,295 billion kWh. In addition, it is important to note that the increase in the production of electric power at atomic electric power stations is even greater for the years of the 10th Five-Year Plan.

The mighty electric-power base which has been created in the USSR has made it possible to realize the re-equipping of the country's economy on the basis of progressive, modern technology and to increase the amount of power available per worker. The nature of electric-power consumption in industry is gradually changing: 10 to 15 years ago, the greater portion of the electricity produced went toward power processes. Today, however, there is a systematic increase underway in the consumption of electric power for production processes.

Today one can name an entire number of new processes, including those which are capable of influencing significantly the efficiency of domestic industry, such as the direct reduction of iron ore, plasma production and refining of metals, plasma synthesis in chemistry, etc. These processes are already being developed on an industrial scale.

A consumer of a considerable portion of the electric power is agriculture, whose amount of power available per unit of production is increasing at a rapid pace.

Thus, one has good reason to say that we are living in an age of growing energy consumption. Apparently, the rate at which consumption will increase in the future will also be kept at a high level. According to available estimates, the consumption of energy in the USSR by the end of the century will increase by a factor of 2.5 in comparison with 1980--this is considering measures which have been taken to economize and to conserve energy.

Up until recently, the development of the electric power industry did not encounter fundamental difficulties. The increase in the production of power was provided for chiefly due to the increase in the extraction and consumption of oil and gas. At the present time, the contribution of oil and gas to worldwide power production exceeds 60 percent.

A sharp increase in the prices for oil and the expansion of its production applications, the increased attention being paid to problems and protecting the environment and the gradual exhaustion of organic fuel deposits is making it necessary to restructure the world's power balance.

Calculations suggest that deposits of cheap oil will be exhausted in the near future and it will become necessary to develop deposits of high-viscosity oil, requiring heating of entire seams of hard rock. It will be necessary to extract the oil in the shelf at depths of 300 to 500 m.

Oil's share in our country's fuel and power balance comprises about 50 percent. Although the predicted reserves of oil in the USSR are still sufficiently large, a considerable portion of this oil is located, unfortunately, in deposits that are considerably inferior with respect to their size and the efficiency with which they can be exploited at the present time. The cost for this portion, therefore, will be higher.

The limited nature of the oil reserves in large-scale exploitable deposits and the tendency of its price to rise cause a reduction in oil's contribution to the fuel and power balance and force us to switch to using it chiefly as a raw material for the chemical and microbiological industries. Of course, energy sources which are capable of replacing oil and gas are numerous: coal, atomic power, solar, wind and geothermal power, the energy of the sea, fusion power, biomass energy, etc. In addition, even if some of these sources are not renewable, some of them at least are inexhaustible (solar, geothermal). If one examines all the primary energy sources, it is easy to come to the conclusion that there are no physical limitations to meeting our energy needs. The lack of inexpensive engineering solutions for the utilization of such forms of energy as solar, wind, geothermal and tidal, however, make it impossible to orient on them as on the basic power sources, at least in the next 50 to 100 years. With regard to the development of fusion power using light nuclei and its possible role in the energy industry of the future, despite the successes already achieved, far from all aspects of the problem can be considered practically solved. We must still solve a number of very complicated engineering and technical problems, including the construction of fusion-power units for demonstration purposes and their check-out in actual operation. This means that several more decades will still be required for the creation of commercial thermonuclear electric power stations.

At the present time, one of the most practicable sources for increasing the generation of electric and thermal power is atomic energy. It is expected that atomic power's contribution to the overall production of electric power by the year 2000 can reach a level of 30 percent in developed countries and approximately 15 percent throughout the world as a whole.

The 11th Congress of the World Power Conference which took place in Munich, West Germany, in September 1980 made it possible to conduct a discussion concerning the demand for atomic power production in developing countries. The power production problems of these countries were one of the main themes of discussion. The overwhelming majority of participants spoke out in favor of the necessity for a broader application of nuclear power in order to curtail the consumption of oil.

The generation of electric power and heat on the basis of fossil fuels is unique with respect to the scale of the material and energy exchange with the environment. The material resources are practically entirely converted into production wastes which enter the environment in the form of gaseous and solid combustion products. It suffices to say that more than 200 million tons of carbon monoxide, more than 50 million tons of various hydrocarbons, almost 150 million tons of sulphur dioxide, more than 50 million tons of nitric oxides and 250 million tons of finely dispersed aerosols are released annually into the earth's atmosphere. Over the last several decades, the concentration of carbon dioxide in the atmosphere has increased by 10 to 12 percent, and the content of dust particles has increased by 12 percent in the last 10 years alone.

The advantages of atomic power production are already being confirmed in practice. In contrast to electric stations which employ traditional forms of fuel, atomic electric stations operate without ash wastes or harmful sulfurous gases and nitric oxides, that is, for all practical purposes, they do not pollute the environment. Atomic electric stations do not require the transport of great amounts of fuel and, subsequently, can be located in the immediate vicinity of the electric power consumer. The cost of electric power at an AES, as a rule, is lower than the cost of power generated at thermal stations.

As far as negative aspects associated with the development of the atomic industry are concerned, one must single out from among them the problems of AES safety from the point of view of the effects on peoples' health and the environment as well as the problem of the accumulation and storage of radioactive wastes and the risk of nuclear weapons proliferation.

For people not acquainted with the problems of power production, the notion of an "atomic station" is frequently associated with a feeling of hazard from radioactive effects. Many years of experience in the operation of a great many AES's shows, however, that the level of radiation around an AES is practically no different from the level of naturally occurring background radiation--the same background radiation which is a normal condition of peoples' existence. Unfortunately, the media still do not explain such facts sufficiently, such as the absence of even a single case of radiation exposure with serious results in the course of almost 2,000 reactor-years of experience in the operation of more than 230 commercial AES power units.

One can assert that at the present time the problem of economical and safe power production at AES's has already been solved. It still remains, however, to solve a number of practical problems associated with the processing of spent nuclear fuel and the storage of radioactive AES wastes, although there is in worldwide practice sufficiently great scientific and technical experience in binding radioactive wastes in solid blocks (bituminization, cementation and other methods) for their safe and protracted storage.

Objections to the broad development of atomic power which are associated with the danger of the proliferation of nuclear weapons derived from spent nuclear fuel from AES's are not justified. An important step in the development of effective measures against such a proliferation of nuclear arms is the Nuclear Arms Nonproliferation Treaty, already with 113 participating States, and the real feasibility of monitoring compliance with this treaty.

In compliance with the Treaty, the States possessing nuclear arms were obliged not to transfer them to anyone whomsoever, while States not possessing them were not to manufacture nor to acquire nuclear arms. Certainly, a most important step in expediting the universal recognition of the conditions of the Nuclear Arms Nonproliferation Treaty is the soonest possible conclusion of a Total and Universal Nuclear Weapons Test Ban Treaty.

At present, nuclear power production in many countries is developing as an independent sector of the electric power industry. Atomic power stations are now operating and are being built in more than 30 of the world's countries. At least another 20 other countries have announced their plans to commence construction of AES's. It is obvious to the majority of the world's power engineers that to refrain from the broad introduction of atomic power would lead unavoidably to an acute reduction in the pace of development of electric power production, for it would require considerable additional expenditures and capital investment for the development of alternate power sources.

The Soviet Union, as is well known, bases the development of its economy on its own fuel and power resources. Our reserves of fuels for power, however, are not unlimited. Our country's fuel and power complex requires ever greater capital investment and labor expenditures. We have to go farther and farther to the north and east into inaccessible and difficult to settle regions in pursuit of coal, oil and gas.

In the Soviet Union, more than 70 percent of all the demand for fuel and power occurs in the country's central regions. At the same time, the potential for growth in the extraction of fuel and power resources in this region is limited. The major potential reserves of all types of fossil fuel are concentrated in Siberia and other of the country's eastern regions. Electric power production in these regions is slated for development on the basis of local reserves, chief among which are exceptionally inexpensive coals from open-pit mines of the Ekibastuz deposit in Kazakhstan, the Kansko-Achinsk deposit in Siberia, natural gas from Tyumenskaya Oblast as well as the hydroresources of rivers in Siberia, the Far East, Central Asia and Kazakhstan.

Calculations show that, under the conditions now developing, it is most advantageous to develop the electric power industry in the central and western regions of the country on the basis of nuclear fuel. A task has been set to insure practically the entire increase of electric power in the region by means of atomic electric stations.

With this as its goal, a major economic program of operations has been developed based on results achieved in the commercial utilization of atomic power in the USSR. There are 18 atomic electric stations with an output of 4 to 6 million kW already operating or being built in various regions from the Kola Peninsula to Armenia and from the Baltic States and the western Ukraine to the Povolzh'ye.

During the years of the 11th Five-Year Plan--the first stage in the USSR's power-production program developed on the initiative of L. I. Brezhnev--the output of atomic electric stations will grow by 24 to 25 million kW. This will make it possible to meet this region's growing demand for electric power without increasing the expenditure of fossil fuels toward this end. The consumption of such fuels will even be reduced somewhat. As soon as the next few years, 5 to 7 million kW of new capacity will be introduced annually at AES's. On the whole, plans have been made to construct large-scale AES's with a total output of 4 to 7 million kW using slow reactors having unit outputs of 1 to 1.5 million kW. Provisions have been made to expand the Kurskaya and Chernobylskaya AES's as well as to construct the Smolenskaya and Ignalinskaya AES's with RBMK-1000 reactors. The South Ukraine, Kalininskaya, Zaporozhskaya, Rostovskaya, Balakovskaya, Khmel'nitskaya, Rovenskaya, Crimean, Bashkirskaya and other atomic electric stations are being built with VVER-1000 reactors. The start-up of the first phases of many of these will be accomplished during the current five-year plan.

The scientific and engineering developments accomplished in recent years have made it possible to utilize nuclear fuel not only for electric power supply, but also for a centralized heating supply for the economy. The expenditure of fossil fuels for low-temperature heat supply exceeds by a factor of approximately 1.5 the expenditure for the generation of electric power, being that low-efficiency units requiring the most valuable forms of fuel are employed to a considerable degree for the generation of heat. Their replacement with atomic power would have great significance in the economy.

The construction of the first atomic TETs is slated to begin near the city of Odessa.

We have also begun construction of special atomic stations for heat supply in Gor'kiy and Voronezh.

Long-range plans for the development of atomic power provide for the introduction of new capacities at AES's to be increased in the 12th Five-Year Plan and for the output of AES's in the country to be brought up to 100 million kW in the 1990's.

We must keep in mind that the scale of atomic power production with slow reactors utilizing only 1 to 2 percent of the mined natural nuclear fuel will in the long run be limited by the naturally occurring reserves of uranium. A significant expansion of atomic power's fuel base will be created by introducing fast reactors into the power industry. These reactors will make it possible to insure expanded breeding of nuclear fuel and will include in the fuel cycle practically all mined uranium, including that which is now disposed of as tailings.

With regard to the technical aspect, these installations are more complicated than thermal reactors. Therefore, their mastery requires considerably more time and effort.

In order to obtain the necessary industrial experience, commercial breeder reactors have already been built and are in operation. These BN-350 breeder reactors are operating in Shevchenko, while in 1980 the most powerful reactor of this type, the BN-600, was introduced at the Beloyarskaya AES. Development is underway of breeder reactors with electric outputs of 800 and 1600 MW.

The planned construction of powerful atomic, thermal and hydroelectric complexes in our country is based upon the accelerated development of domestic machine construction, which in the 11th Five-Year Plan must be raised to a new level. The "Basic Directions for the Economic and Social Development of the USSR for 1981-1985 and for the Period to 1990" makes provisions to insure a considerable increase in the production of equipment for atomic, hydroelectric and thermal power stations, including atomic reactors of 1 to 1.5 million kW. Plans have been made to manufacture and deliver the first atomic reactors for heat supply and to develop new designs for power units with breeder reactors and equipment for highly controllable power units of 500,000-kW capacity.

Thus, at this modern stage, electric power production is undergoing considerable structural and technological rebuilding associated first of all with increasing the contribution of atomic electric stations and coal-fired thermal stations. This rebuilding is likewise expressed in the further development of power systems on a countrywide or multicountry scale. For example, the USSR's Unified Power System has already made it possible to efficiently combine various types of electric stations and better utilize the country's fuel and power reserves. We have achieved in our country a noticeable savings of fuel due to the unification of power systems and streamlining of the operation of power equipment.

A specific characteristic of the USSR's power industry is the mass application of the combined generation of electric power and heat. Electric stations which provide cities and industry with electric power and heat now comprise more than one-third of the rated power of the country's thermal stations. The centralization of heat supply on the basis of heat-and-electric power stations results in a considerable saving of fuel and is efficient from an ecological point of view. These advantages will increase even more with the commissioning of atomic heat-and-power stations (ATETs) and atomic heat-supply stations (AST). Thus, the development of central heating is becoming one of the most important directions in the purposeful energy-conservation policy being carried out in our country.

An increase in the scale of electric-power production requires its further concentration and the development of intersystem and inter-State electric lines. At the present time, there exist in Europe several large-scale inter-State power amalgamations (NORDEL', SYUDEL', SKPPE [Expansions not provided.], etc.). Over the course of a number of years, the "Mir" power system has been functioning successfully as a large-scale power association of the member nations of CEMA. This system unites the power systems of Bulgaria, Hungary, East Germany, Poland, Romania, the Soviet Union and Czechoslovakia.

From our point of view, the need to unite the power systems of different countries, particularly the countries of Europe, has been coming on for a long time. Among other things, this problem has for a long period of time been discussed within the framework of the Economic Commission for Europe of the UN. The task of unifying the power systems of the countries of Eastern and Western Europe certainly has great economic and industrial-technical significance.

Trade and exchange of electric power between different countries is a mutually profitable affair. Electric power arrives in the form of a commodity--an energy carrier possessing extremely great value to the consumer and accumulating in itself the greatest investment of manpower and reified labor, calculated in thermal units. The presence of powerful international electric lines makes it possible for the participating sides to realize a number of advantages, such as: the offering of multilateral assistance; the guarantee of mutual reserves in the power systems and the capacity to realize an exchange of peak output based on the time of day and the season as well as differences in climatic and natural conditions, etc.

Additionally, the creation of electric communications of sufficient capacity and a system for the trade and exchange of electric power between the power associations of Eastern and Western Europe would make it possible to reduce considerably the demand for the installed power of electric power stations in the associations and to produce electric power there, where it is most convenient and profitable. An important aspect of the cooperation would be the construction of large-scale power-production installations through the joint efforts of the participating nations. These would be installations of systemwide significance; for example, electric power stations with high-output units and electric transmission lines of great capacity.

During the 11th Five-Year Plan, the first superhigh-voltage electric transmission lines will be commissioned in the USSR--the 1,500-kV direct-current Ekibastuz-Center line and the 1,150-kV alternating-current Ekibastuz-Urals line.

The further development of the USSR's Unified Power System will facilitate the shunting of outputs and will increase the reliability of the power supply to the consumers.

Hydroelectric power stations primarily will help to cover the variable portion of the daily load schedules. They resolve this problem fully in regions rich in hydroresources.

In the northwest, the south and the center of the country's European sector where the construction of efficient GES's is limited, shuntable hydroelectric pumped storage power stations (GAES) and gas-turbine installations will be built. The GAES's successfully equalize the operational modes of base stations by covering the peak portion of the load and consuming power during the nighttime. Moreover, a GAES is an efficient and mobile back-up when disconnecting large power units of thermal and atomic power stations or intersystem lines.

The further growth of electric-power production and the planned, expanded construction of power networks in the 11th Five-Year Plan will elevate the electrification of all sectors of industry, agriculture and domestic life to a new, higher level.

The course taken by the 26th CPSU Congress toward rebuilding the structure of the fuel and power balance and of the power industry will make it possible to insure the necessary rate of growth of electric-power and heat production, based upon the planned development of all sectors of our country's economy.

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ELECTRIC POWER

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DEVELOPMENT STAGES OF NOVOVORONEZHSKAYA AES DESCRIBED

Moscow ELEKTRICHESKIYE STANTSII in Russian No 7, Jul 81 pp 13-15

[Article by engineers V. A. Zverev, V. K. Sedov and V. A. Vikin: "The Novovoronezhskaya AES at a New Stage of Development"]

[Text] The 17 years of experience in the operation of the Novovoronezhskaya AES make it possible to single out certain characteristic stages in the development of atomic power production in the USSR through the use of water-cooled power reactors.

In the first stage (1964-1969), the accuracy and viability of the scientific and technical principles embodied in the first power unit with a water-cooled reactor were checked. Primary attention at this stage was directed toward developing the conditions for safe and reliable operation of this type of nuclear steam-generating unit and the demonstration of its technical and economic possibilities.

The second stage (1970-1973) marked the development of a test commercial prototype nuclear steam-generating unit of increased output in the second power unit and prototypes of a series of power units with VVER-440 reactors (second-generation reactors).

The primary tasks of this stage were the transformation of the Novovoronezhskaya AES into a powerful energy-supplying source of the RSFSR's central chernozem region and a large-scale communications center for the power systems of the south and central USSR; the significant increase in the economic effectiveness of the station's operation; and the achievement of a competitive status for the station with the thermal electric power stations in the European sector of the USSR.

In the third stage (1974-1980), problems were solved regarding further improvement in the station's operation, the search for reserves of all equipment and the development of techniques of quality overhaul and the reduction of the time necessary for overhaul. A major goal of this stage was realized on this basis--a considerable improvement in the indicators for the economy of operation of all four operating units. At the same time, this was the stage of construction and start-up of the first prototype of a 1 million-kW atomic generating set with a third-generation VVER-1000 reactor.

Having realized the resolutions of the 25th CPSU Congress, the Novovoronezhskaya AES power engineers and operators carried out the start-up of the fifth unit on 30 May 1980 in conjunction with planning, scientific research and design organizations and equipment-manufacturing enterprises. The installed output of the five units at the Novovoronezhskaya AES reached 2.45 million kW.

The fifth unit was brought up to its design level of thermal output on the eve of the 26th CPSU Congress, 20 February 1981.

In the 11th Five-Year Plan, beginning with 1981, this electric power station must insure an annual generation of 15.7 to 16 million kWh, which will amount to about 1 percent of all the electric power to be generated in our country.

At this moment, the operators of the Novovoronezhskaya AES have entered a new, fourth stage of development for the station--familiarization with the design indicators of the first prototype of the VVER-1000 series.

The dynamics of the increase in the station's indicators and the primary characteristic indicators are illustrated by the data in table 1.

In proportion to the growth in the unit output of the equipment, there has been an increase in the safety and reliability requirements for AES's. These requirements have been realized to the maximum extent possible in the fifth power unit. The presence of active and passive independent three-channel safety systems in combination with a reliable, hermetically-sealed jacket for the entire reactor compartment of the unit make it possible to insure localization of the maximum design emergency with a breach of the largest-diameter pipeline.

Unique electrical equipment, much of which is not similar to anything in Soviet atomic machine-construction practice, has been installed and is being operated as part of the fifth power unit.

Table 1

Indicator	VVER-210	VVER-365	VVER-440	VVER-1000
Unit No.	1	2	3,4	5
Year of introduction	1964	1969	1971-72	1980
Reactor output, MW:				
thermal	760	1320	1375	3000
electric (gross)	210	365	440*	1000
Pressure, kg/cm^2:				
heat exchanger in first circuit	100	105	125	160
saturated steam ahead of turbines	29	30	44	60
Number of turbogenerators	3	5	4	2
Turbogenerator unit output	70	73	220	500
Portion for auxiliary power, %:	8.0	7.3	6.8	4.7
Efficiency, %:				
gross	27.7	27.6	32*	33
net	25.5	25.7	29.7*	31.7

* with a pressure in the condenser of 0.035 kg/cm^2

Great experience was accumulated during the course of operation of the power units at various stages. This experience made it possible to improve the designs and transfer those improvements to other AES's, either already operational or under construction. It was also possible to achieve continuously, from year to year, an improvement in the technical and economic indicators for the operation, reliability and safety of AES's.

Table 2 presents figures for the generation and output of electric power and the growth in these figures for various stages in the operation of the Novovoronezhskaya AES. Without going into a detailed analysis, we will note that a considerable improvement in the indicators was achieved during the periods of the second and third stages at an unchanging level of installed output, as well as during the 10th and 11th Five-Year Plans. This reflected the work of the operators collective on increasing the level of AES equipment operation on the whole, on raising the level of thermal economy and reducing the expenditures for auxiliary power.

From 1975 through 1979 as well as during the 10th Five-Year Plan--the period for mastering the operation of the four operational units--the most stable operation of the station was achieved with an output of 9.7 to 10.5 billion kWh. In this case, deviations this way or that from the annual average (10.1 billion kWh) can be explained by planned downtime of the units for overload and scheduled preventive maintenance.

Table 2

Stage of work	Electric-power generation billions kWh	Electric-power generation %	Electric-power output billions kWh	Electric-power output %
1 Oct 1964 - 1 Oct 1969	6.44	100	5.87	100
1 Oct 1969 - 1 Oct 1974	24.72	380	22.67	390
1 Oct 1974 - 1 Oct 1979	49.92	780	46.11	790
1966 - 1970	7.22	100	6.58	100
1971 - 1975	34.92	480	32.14	490
1976 - 1980	51.6 1.1 on the fifth unit	710	47.56	720
1981-1985 (planned)	78.4	1090	71.87	1090

Note: From 30 May 1980 to 1 January 1981, the power of the fifth unit was developed to a level 75-80 percent of nominal.

In order to maintain a high level of readiness to accept the loads of the operational power units which have been working for 16, 11, 9 and 8 years, correspondingly, modernization, the quality and methods of repair and the renovation of equipment and the engineering systems acquire great significance.

These operations are carried out according to plan at the Novovoronezhskaya AES. For example, during the last two years of the 10th Five-Year Plan:

two 30-phase turbogenerator stators were replaced with type TVV-220-2A 60-phase stators. Replacement is planned for the stators of two more generators;

the upper unit of the reactor in the fourth power unit was renovated, with the sheathing pipes and drives for the control and safety system (SUZ) being replaced with commercial equipment of increased reliability;

a production-line method was applied to repair a great amount of pumping equipment and many electric motors;

the complete replacement of the tube banks of the PND-5, the turbine condensers and the oil coolers with K-220-44 tubes was carried out; the modernization of the condensers and the PND on the AK-70 and K-75 turbines is being carried out according to plan;

a method of vacuum drying and cleaning the pipe still of the condensers was introduced in two AK-70 turbines and four of the K-220-44's;

the VVER-440 reactors were converted to replenishment with standard-enrichment fuel. These and many other measures have provided a saving of more than 1 million rubles per year due to the reduction in unplanned downtime and the increase in the economy of the equipment.

The ever-growing requirements for safety at atomic electric stations can be guaranteed through the profound theoretical knowledge and on-the-job skills of the operational personnel, the high degree of operational efficiency and equipment maintenance and the application of computers and automatic means of monitoring and control.

The operational personnel who control and maintain the reactor yearly undergo training, a check of their skill in controlling the reactor and on-the-job training at the Novovoronezhskaya AES training center on a VVER-440 simulator.

In addition to the Novovoronezhskaya AES operators, foreign specialists and personnel from AES's currently under construction in our country undergo training on the simulator and in classrooms on equipment mock-ups.

The first four power units do not differ significantly from one another with respect to the equipping of the units with automatic control devices in view of the fact thatit is these units that were the objects of research and development of test prototypes of devices and instruments for the automatic systems used at present on the fifth unit. A highly accurate automatic power regulator for the reactor (ARM-5), the "Uran-V" computer control complex, the reactor's internal monitoring system "Gindukush," the ASUT-500 automated control system and the input of information to the telecranes in a color display concerning the "on" status and operational conditions of the engineering systems make it possible for the operations personnel to analyze correctly and in a timely manner the operation of equipment and to take the necessary measures and actions in order to insure a high degree of safety and economy.

As was noted earlier, an atomic electric station can exert an influence on the environment under emergency conditions when there is a breach of the maximum-diameter conduit in the first conduit. Such a failure has almost zero probability of occurring and its constancy is insured through the periodic monitoring of the metal and recomputation of its stability, based on the influence of various factors specific to the AES.

Under normal or other emergency operational conditions, the Novovoronezhskaya AES exerts no negative influences, as observational experience over its entire period of operation has shown.

During the development of long-term plans for the station based on the rich experience accumulated during the operation and servicing of the equipment and the scientific research done on the reactors at hand, it was recognized as expedient to build a number of scientific and industrial subdivisions and enterprises at the Novovoronezhskaya AES:

an engineering laboratory building for research into spent fuel and irradiated construction materials;

a VVER-1000 simulator and an expansion of the training center, with consideration being given to long-range plans for the development of the USSR atomic power industry in the 11th Five-Year Plan and up to 1990;

a production repair enterprise for the AES;

an automated AES control center with the installation of back-up control panels for the power units;

an expansion of the set-up shop and the organization of a start-up and adjustment enterprise on its basis.

Aside from developing the rated power of the fifth power unit and bringing its technical and economic indicators up to the norm, the fourth stage of development of the Novovoronezhskaya AES includes plans for a broad complex of measures directed at further increasing the level of operation and improving the repair service, the realization of which will make it possible to increase the efficiency of utilization of atomic power.

The station's specialists in conjunction with planning and design organizations are examining the issue of modernizing the reactor of the first unit, which possesses a relatively small output. There are several possible methods for utilizing it which in any case will provide positive results:

its utilization for research purposes;

its continued operation with parameters for the generation of electric or thermal power for the daily needs of the population and the economy.

The implementation of a central-heating project for the power workers' housing settlement using the operational power units has already begun at the station.

The introduction of the first phase of a fishery utilizing the heated waste water is planned for 1982-1983. Thus, the resolution of the USSR Council of Ministers regarding improvement of the operational economy and efficient utilization of fuel and power resources is being implemented.

The Novovoronezhskaya power-workers collective is full of resolve and creative forces for the successful fulfillment of the tasks set by the 26th CPSU Congress.

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ELECTRIC POWER

KALININSKAYA AES CONSTRUCTION PROGRESS

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/Article: "At the Construction Projects of the Five-Year Plan: the Kalininskaya AES"/

/Text/ One of the most important power projects in the central region of the country is the Kalininskaya AES with a rated capacity of 4 million kW and VVER-1000 reactors. The first block of the AES should be put into operation next year.

It was begun in April 1981. The concreting of the containment vessel of the reactor with the use of a sliding concrete form designed by Orgenergostroy is under way; the well of the reactor is being concreted, work is being performed in the compartments within the reactor; the frame of the turbine house has been erected along the 10th axis, the deaerator stack has been erected along the 13th axis, the underground part of the block pump house has been built and the precast reinforced concrete structural members of the underground part of the engineering and general building have been erected.

Since the start of construction 102,965 m^2 of housing have been put into operation, 3 kindergartens, a school for 1,176 pupils, a trade center, a drugstore and 3 cafes have been built.

The amount of work performed by the construction workers during the first quarter of 1981 increased by 37 percent as compared with the same quarter last year.

At the construction project there are good labor collectives, which invariably fulfill both the plan assignments and the increased socialist obligations, for example, the section of the administration of mechanization and special operations and the section of the Sevzapenergomontazh Trust. At the Kalininskaya AES there are also outstanding brigades and crews. Thus, the crew of communist labor of bulldozer drivers of V. I. Rodonezhskiy by the day of the opening of the 26th CPSU Congress had fulfilled the plan of 2 months by 160 percent; the crew of excavator operators of N. M. Novozhilov also exceeded the socialist obligations.

It would seem that it is possible only to rejoice at the achievements of the construction workers and installers, who are building the Kalininskaya AES.

Unfortunately, it just "would seem."

The house newspaper of the Kalininskaya AES on the threshold of the new year of 1981 reported:

"Let us also keep in mind our shortcomings. The plan of the construction of the facilities of the nuclear electric power station, housing and social, cultural and personal facilities is not being fulfilled. There are many unfinished projects. The managers of the construction and installation sections and the administrations, the secretaries of the party organizations and the communists must take decisive steps to improve the construction of purification facilities, the hospital complex, the dormitory, apartment houses and the main projects of the AES."

To know the shortcomings and to remember them means to act energetically in the direction of the improvement of matters at the construction site. However, things have not budged an inch.

Of course, it is possible to find objective reasons--the lack of skilled personnel at such facilities as the reactor department, the transfer to the start-up Kol'skaya AES of the collective of the construction administration of the Novovoronezhskaya AES, which had earlier been sent here, to the Kalininskaya AES, and so on and so forth.

But are there really few still undiscovered reserves at the construction project proper? The competition at the construction site has been organized, to put it mildly, not in the best way: a pitiful number of brigades are covered by such an advanced form of labor as the brigade contract, labor productivity as a whole at the construction project is low, hence such a very unpleasant fact--the plan of the first quarter of 1981 was fulfilled by only 53 percent.

A field collegium of the USSR Ministry of Power and Electrification, which was held on 10 April 1981 under the chairmanship of USSR Minister of Power and Electrification P. S. Neporozhniy, was devoted to the analysis of the formed situation at the construction site of the Kalininskaya AES.

The collegium noted that the construction of the Kalininskaya AES is being carried out without the proper engineering preparation, with a serious lag with respect to the main directions of work and with a low standard of performance. The nonfulfillment of the plans on the placement into operation of housing and social, cultural and personal facilities is causing additional difficulties in the build-up of the collective of construction workers. All this is threatening to upset the timely placement into operation of the first power block of the Kalininskaya AES.

The collegium outlined urgent and effective steps on assisting the collective. It is the duty of the construction workers and installers of the Kalininskaya AES to take all the necessary steps and to utilize the available reserves in order to fulfill the plan assignments and to place into operation the first power block with a capacity of 1 million kW in 1982.

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CONTROLLING PROCESS OF EXPLORING FOR OIL AND GAS DEPOSITS

Moscow UPRAVLENIYE PROTSESSOM RAZVEDKI NEFTYANYKH I GAZOVYKH MESTOROZHDENIY in Russian 1980 (signed to press 18 Mar 80) pp 1-9, 174-176

[Annotation, introduction and table of contents from book "Controlling Process of Exploring Oil and Gas Fields," by Valentin Borisovich Vasil'yev, Izdatel'stvo "Nedra," 1300 copies, 176 pages]

[Text] The book examines procedural questions of exploring oil and gas fields in terms of the possible application of economic-mathematical models and computers to controlling the process of exploration.

The main procedural concepts are analyzed with regard for the main trends in exploration and the geological characteristics of the country's most promising regions. Questions are examined of evaluating the long-term reserves with the help of statistical models, determination of the well arrangement systems and minimization of their number. Parameters are defined for controlling the process of oil and gas exploration. A plan is suggested for controlling exploration of oil and gas fields using a computer. Characteristics are presented of the economic-mathematical model and an algorithm for solving the problem, elements of information, mathematical and technical support for realization of the plan. The simulation potentialities of the model are shown.

The book is designed for specialists involved in exploring oil and gas fields.

Seventeen tables, 57 illustrations, 86 bibliographic entries.

Introduction

The strategy of geological exploration for oil and gas for the near future follows from the decisions of the 25th CPSU Congress. Subsequent developments of these most important decisions stipulate concentration of the chief monetary, material and labor resources in the main directions, which include:

concentration of exploratory-development drilling in the promising regions of the country where there are real prerequisites for obtaining increments in oil and gas reserves (West Siberia, East Siberia, Far East, Timano-Pechora province, Central Asia and the Caspian syneclise);

guarantee of the maximum increase in oil and gas reserves in the regions of the European sector of the USSR (Komi ASSR, Arkhangel'skaya, Orenburgskaya, Permskaya and Astrakhanskaya Oblasts, Udmurt ASSR, Ukrainian SSR, Belorussian SSR, Georgian SSR) in order to maintain the extraction levels attained here;

increase in the volumes of regional and exploratory geophysical work and drastic improvement in their technical level, in the first place, in the new promising but poorly studied regions of East Siberia, Far East, Uzbek SSR, and Turkmen SSR.

The scientifically substantiated selection of the main trends in exploratory-development work will create the prerequisites for the most efficient arrangement of the work and the corresponding increase in oil and gas reserves for each promising region.

The West Siberian oil and gas province is one the country's leading regions for extraction of oil, natural gas and condensate. Increase in the reserves of these minerals in all regions of the country, including West Siberia is becoming the most important national economic task.

L. I. Brezhnev stressed the enormous importance of the heroic accomplishments of the Siberian oil workers in his speech at the 18th Komsomol Congress.

"We are faced with living on the Tyumen reserves for many years still. In the next 10 years, the primary increase in extraction of oil, gas and the valuable chemical raw material that is produced from them," stated L. I. Brezhnev, "we are counting on obtaining precisely because of Tyumen'. Consequently, a new and more complicated stage of development of West Siberia is approaching, or more correctly, has already approached. We are faced with doubling and tripling the volumes of this work there."[1]

Realization of the program planned by the party will require further evolution of exploration and simultaneously with the industrial exploration of new areas, completion of exploration on the started areas in the shortest possible times, as well as start-up of new fields.

A primary measure is increase in the economic efficiency of exploration by searching for and introducing new techniques of exploration. There is also the problem of creating highly effective methods of systemitizing and processing information, as well as working out methods to reduce outlays for exploration and the efficient arrangement of wells.

Intensification of the geological exploration process entails a definite rise in the volumes of drilling operations. This in turn determines the need to improve the system of control. In addition, when exploratory work for oil and gas is done, it is necessary to improve its quality. Guarantee of a reliable geophysical base for the planned indicators and the maximum thoroughness in determining the exploration network are an important starting condition for the success of the exploration process. Since it is carried out under conditions of indefiniteness and each new information source can significantly alter the concept of the facility, it is expedient to model the different versions of its condition so that decision making is simulated and the need for outlays of some material resources is eliminated. But the actual process of conducting exploration must be under constant control which guarantees conditions for making timely and optimal decisions regarding its development.

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[1] L. I. Brezhnev, "Speech at the 18th Komsomol Congress 25 April 1978," KOMMUNIST, No 7, 1978, p 13.

The concept of the quality of geological exploration does not have a distinct quantitative expression. This usually infers a multifaceted complex of conditions which are difficult and practically unformalizable. Some of them can be expressed quantitatively. For example, hydrocarbon reserves are considered to be prepared more qualitatively if they suit a higher category with other conditions equal. Certain economic factors further come into operation. Higher quality work should be considered that done in which a lower cost of a unit of explored reserves was attained. The latter is possible with a reduction in the number of wells with low information content.

The problem of improving the efficiency of geological exploration is associated in the closest possible way with minimizing the number of development wells. Work in this direction has been underway for a long time.

There are a considerable number of developments whose usefulness is undoubted. It is promising to apply to the solution to the problem of optimizing the exploration process the main principles of systems analysis in combination with economic and mathematical models and computer equipment.

If we conceive that the expediencey of developing a field in any one of its links is determined by the quantity and quality of the prepared reserves, then the meaning of exploration can be seen in evaluating the parameters of the system which governs the calculation of reserves and other geological, technological and economic indicators.

Exploration of oil and gas wealth is a great national economic problem. It cannot be solved in one approach, however, it can be divided into parts that are more accessible for study and resolution. Parts of the problem in descending order are conducting of exploration on the territory of the oil and gas province, oil and gas oblast, and finally, typical groups of fields, individual fields and beds. A large problem is to define the situation which characterizes the difference between the necessary output, the attainment of the planned volume of reserves prepared by some schedule, and the existing output, the current state of the reserves.

Thus, the problem of exploration is the desire to obtain industrial reserves in the predicted or higher volumes with limited allocations. The exploration system is that tool used to solve this problem completely or by parts. Following S. Optner [58], by control is meant that state of the system where it is under control.

Control of the exploration process is first of all resolution of questions of operational control. This is therefore a decision making process to a considerable degree. It is assumed that it is reserved for man. In the "man-machine" system which needs to be realized for control, the machine only prepares information for decision making with the help of a mathematical tool.

Based on this concept, it should be assumed that the model of control contains elements of behaviorality. In the "man-machine" system, human activity is the most important component. Modelling this activity is still difficult, because it is inadequate to the real process. Man or a collective of people working in technical or social systems, implement basically different procedures of activity which include acknowledgment and realization of meanings, goals and values of their own work. They critically rethink it by using the broadest set of cultural and social norms, values and ideals. These aspects of human activity are not successfully considered in the language of systems equipment [30].

Ye. S. Venttsel' [18] defines a decision as "any definite selection of parameters which depend on us," while she calls the optimal "decisions which are preferable to others for some reasons." In studying the decision making mechanism, I. P. Shubkina [83] notes that the process of decision making and situations in which decisions have to be made are, on the one hand, common concepts, and as such they are indistinct and do not have clearly defined boundaries. On the other hand, these same concepts are used in the theory of studying operations and in other areas of science, and therefore, they require formal, or at least more precise definitions. However, in the decision making process, two parts are isolated in its mechanism: one which can still only be defined on a qualitative, nonformal level (in particular, analysis of information regarding the process or final selection of a decision), and another, for example, compilation of a model of the process whose description requires quantitative, formal methods.

This approach to studying the decision making mechanism can be viewed as a combination of methods used in analyzing large systems and in studying operations. In analyzing large systems, the main aspect is to search for the actual decisions among which a selection can be made, while in studying the operations, the main aspect is the methods of selecting the decisions that are permissible or the best.

E. Kveyd [41] notes that although systems analysis often uses the same mathematical methods, it is associated with that class of problems whose difficulties consist of the need to decide what should be done, and not simply how to do it.

The statement of Ye. Z. Mayminas [44] is also important. It asserts that even in those cases where in the process of making control decisions, quantitative analysis plays the chief role, the system that is oriented on the use of the methods of studying operations can never yield information that is sufficient for selecting a method of actions.

The decision making process consists of formalizable and nonformalizable stages. Therefore the problem of searching for rational limits of converging these stages and the mutual transition of them without losing quality has not yet been solved. The main path to solving it is for nonformal description to organically precede the formal calculations, and for their corresponding interpretation to be completed in the act of final decision making by man.

It is expedient to select approximately this path in solving the problem of controlling exploration. It is first of all necessary to find the criteria which define the condition of exploration of the field, the main parameters of control, their change in the process of exploration, degree of influence on the results of work so that:

we approach resolution of the question of limiting the number of development wells and the resources invested in exploration of oil and gas fields;

a computer is connected to control of the process of exploring oil and gas fields.

The author has shown the possibility and expediency of formalizing the functional part of the task of controlling the process of exploration and its presentation in the form of an economic-mathematical model with subsequent program support and realization on a computer [16]. It is known that economic-mathematical models and computers are applicable in those cases where the problem has an optimization nature and possesses multiple versions of solutions. Here a change in any parameter of the system which is governed by the possibility of a fairly broad maneuver of resources in a temporal respect, causes its new condition, while the latter determines the conditions for the development of different versions of the condition of the system, and correspondingly, making of a controlling decision. It also provides for simulation of the exploration process with playing out of its individual stages on the computer in a search for the quantitatively defined best version of well arrangement.

Thus, the essence of the base economic-mathematical model is control over the condition of the changes in the main geological and technological parameters of the bed and the economic characteristics of the process that are recorded at some stage.

Computer control gurantees the output of objective and adequate information, but the final judgment regarding the condition of the system and making of the controlling decision are reserved for man.

The majority of books on the technique of exploring oil and gas fields to a considerable measure treat the geological aspects of the problem. Questions of optimizing and controlling the exploration process have not been sufficiently examined.

The increasing rates of development of the oil and gas industry force us to make a new and more attentive examination of the need to use new and progressive techniques and methods of controlling the exploration process.

It is becoming obvious that further introduction of quantitative procedures and characteristics into the exploration technique, and improvement in the level of adequacy and objectivity of information are an important reserve for intensifying exploration for oil and gas.

This book has analyzed method questions of exploration and the possibility of quantitative forms of solving them. It covers the possible minimization in the number of development wells and suggests planning solutions to controlling the exploration process which stipulate the extensive involvement of computers.

Based on a comparative analysis of the outlook for oil and gas content, the first chapter defines the main trends in exploration for oil and gas in the country. It presents geological characteristics of the regions in which search and exploration for oil and gas fields have been primarily developed. As in the entire work, this section gives considerable coverage to the West Siberian oil and gas province. It examines certain features of the oil and gas fields.

The second chapter analyzes the method concepts of exploration for oil and gas. It makes a concise survey of the works on optimizing the exploration process. It examines questions of evaluating the long-term geological reserves of the field before the beginning of exploration. It presents a technique for applying regressive models for this purpose. It analyzes the stages in exploration and covers tasks that can be solved at each stage.

Based on the geological characteristics for the main conditions of occurrence of oil and gas, systems are examined for the arrangement of development wells, and preference is given to the profile system. Certain methods are presented for determining the distances between the profiles and wells in the profiles. Examples are given from the experience of exploration work on certain fields in West Siberia.

The preliminary conclusion is drawn that the use of an efficient technique and control of the condition of exploration of the fields will permit reduction in the number of development wells.

The third chapter covers the selection of parameters to control the process of oil and gas exploration and their changes during exploration, as well as determination of the necessary number of wells. It analyzes the dependence of field reserves on the change in calculated parameters. It presents graphs showing the fluctuations in individual parameters in the exploration process, as well as the statistical models to determine the minimum number of wells needed for exploration.

An analysis is made and the dependence of the state of preparation of the oil and gas reserves by categories on the number of development wells is established.

The fourth chapter suggests a plan for controlling exploration of oil and gas fields using computers. It examines the logical-economic and method concepts of questions of developing control of exploration, and defines the concept of the object of control, and the technical-economic indicators necessary for control. It presents the characteristics of the economic-mathematical model and algorithm for solving the control problem.

Elements are presented of the information, mathematical and technical support of the plan realization. Simulation potentialities of the model and its realization using computers in specific examples are shown.

The conclusion formulates the main conclusion on the presented material.

All the method recommendations presented in the book are aimed at further improvement in the effectiveness of exploration for oil and gas.

The presented material is based on personal developments of the author, experience accumulated by him during work in West Siberia, in the Irkutsk amphitheater, and in the Caspian basin, as well as on the use of domestic publications.

The author is grateful for assistance in collecting materials, mainly on questions of information, technical and mathematical support of the control project, as well as for supply of test calculations on the computer to engineers S. N. Zenkov and V.N. Ivanova. The author considers it his pleasant duty to express his gratitude to corresponding member of the USSR Academy of Sciences, Professor I. I. Nesterov for valuable advice and assistance which promoted the creation of the book.

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